End-to-End Modeling of AFTA Coronagraphs (Lyot configuration)

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Model Evaluation Procedure

- Create PROPER model based on Zemax layouts provided by Mike Rud
  - HLC, VVC, & shaped pupil share same layout
- Verify that the PROPER model results match the performance expected by the advocate for an *unaberrated* system (no WFC)
- Run end-to-end models with WFC in an aberrated system over a specified bandpass to generate a dark hole
  - Static system, no jitter
  - No mask errors
- Starting at dark hole solution and without any further WFC, propagate individual Zernike aberrations through the system at various levels to gauge the coronagraph low order wavefront error sensitivities
  - Fields are sent to Luis Marchen and Stuart Shaklan for evaluation
- Evaluate solution for 1.6 mas pointing jitter
- Send dark hole field to Wes Traub for science metrics evaluation
  - Include field transmission pattern, planet PSF properties
  - Need a low-order-aberration-perturbed field for PSF subtraction error estimate?
  - Wes to evaluate 1.6 mas jitter field?

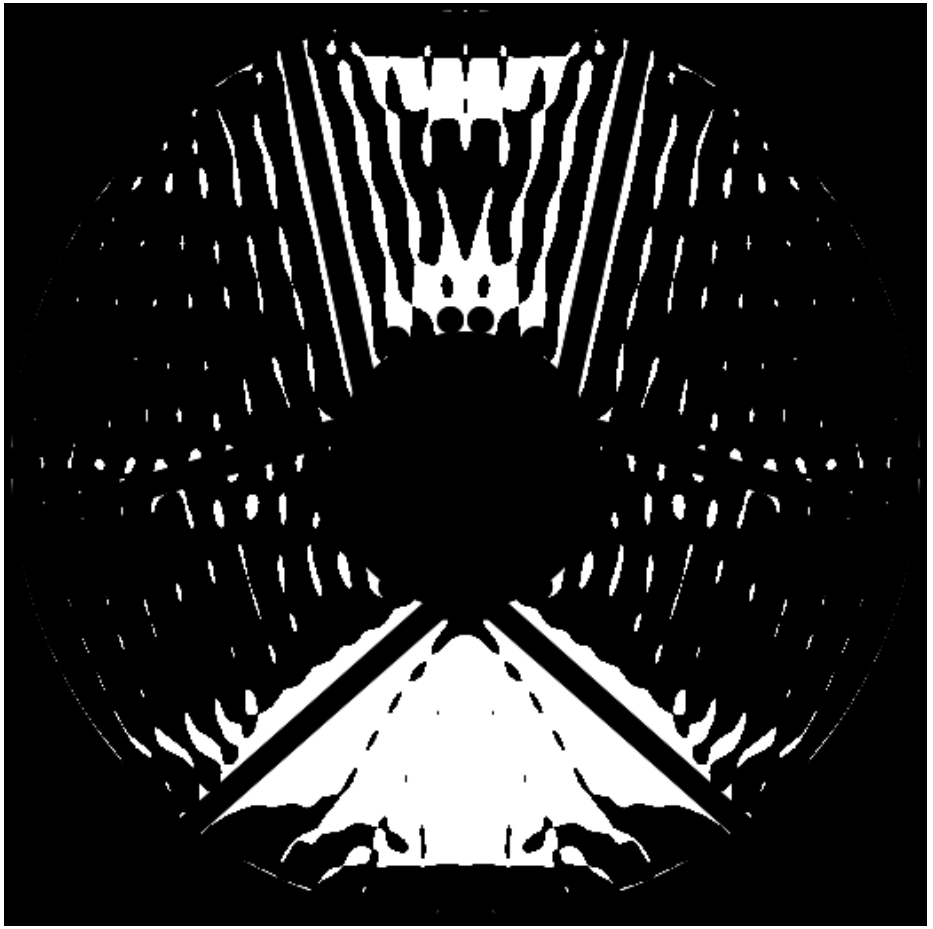
NOTE: The results shown here utilize non-final designs for demonstration only. Revised designs have been submitted but have not yet been evaluated.

Shaped Pupils

- Three shaped pupils delivered 14 Oct 2013
- A.J. Riggs specified one for primary analysis
  - SP_AFTA_hN512_erNo_c8_37WA24_60deg_tr22pt7pct.fits
- Layout uses field stop at intermediate focus after shaped pupil mask
- Two runs of EFC to generate 2-sided, full-size and 1-sided, small-size dark holes
  - 522 – 578 nm
  - 5 wavelengths “sensed” and controlled

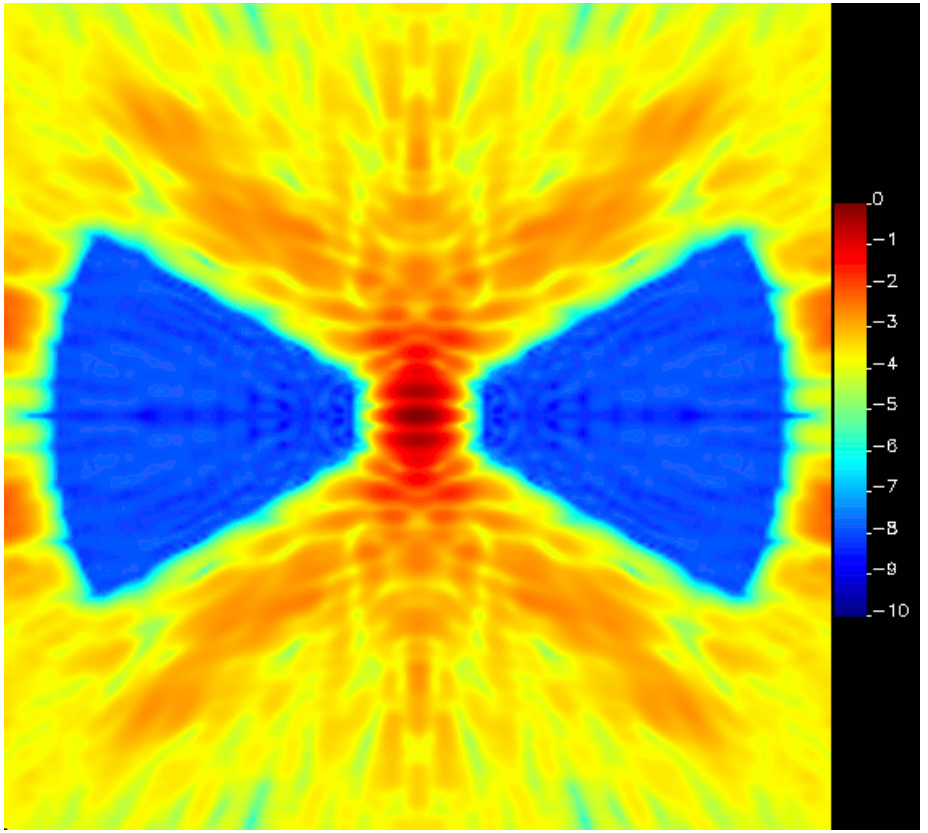
Shaped Pupil (522-578 nm)

SP_AFTA_hN512_erNo_c8_37WA24_60deg_tr22pt7pct.fits



Mask transmission = 22%
relative to obscured AFTA pupil

No aberrations

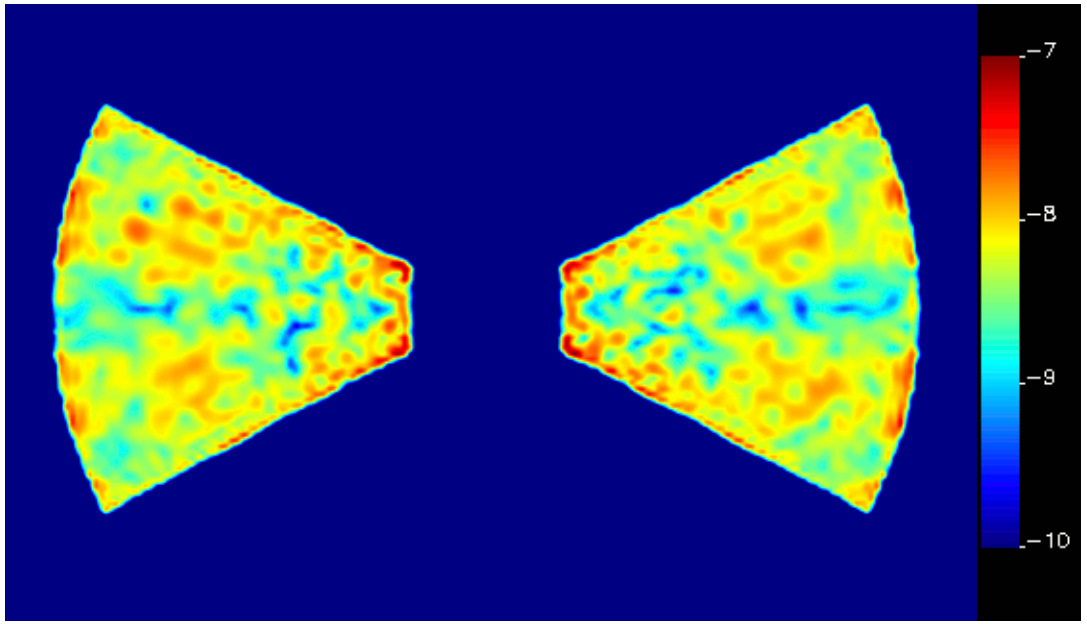


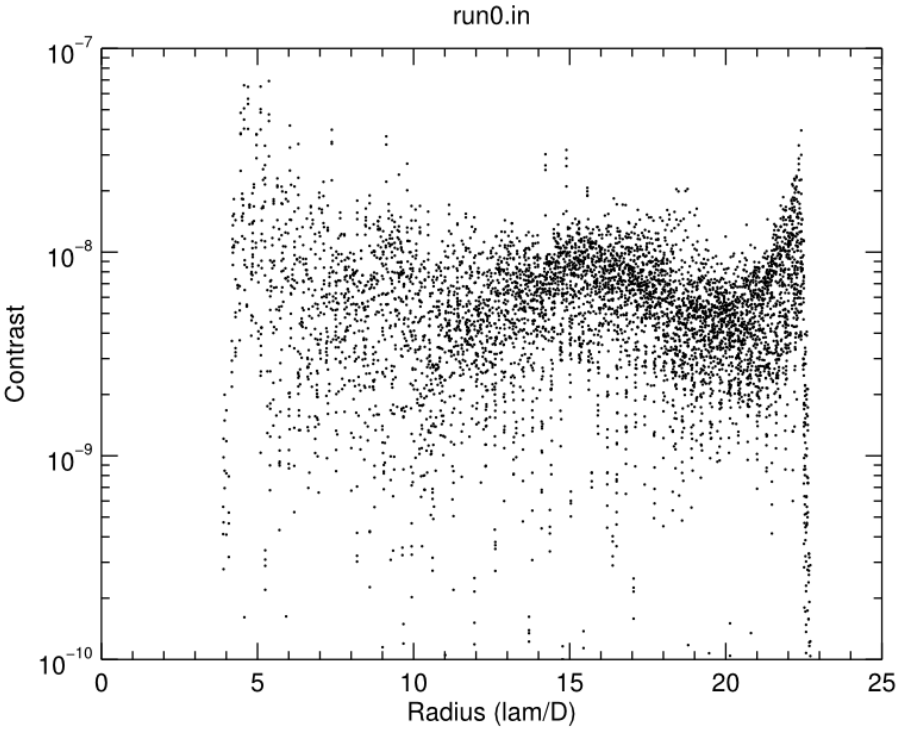
Mean contrast = 1.3×10^{-8}

2 Sided, Full Size Dark Hole

Post-EFC

With aberrations





Opening angle = 56°

$|X| \geq 4\ \lambda/D,\ R \leq 22.5\ \lambda/D$

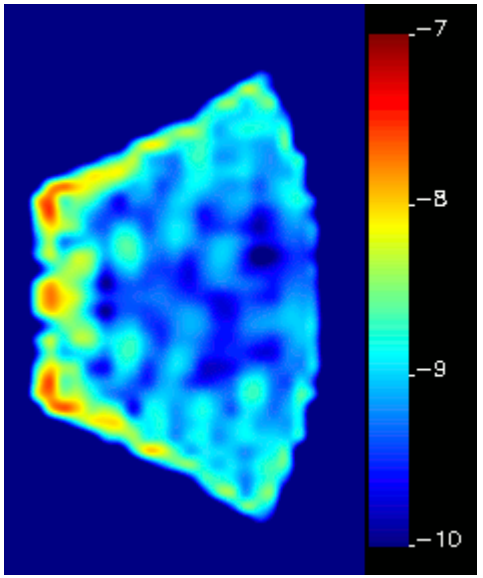
Mean contrast (full field) = 6.2×10^{-9}

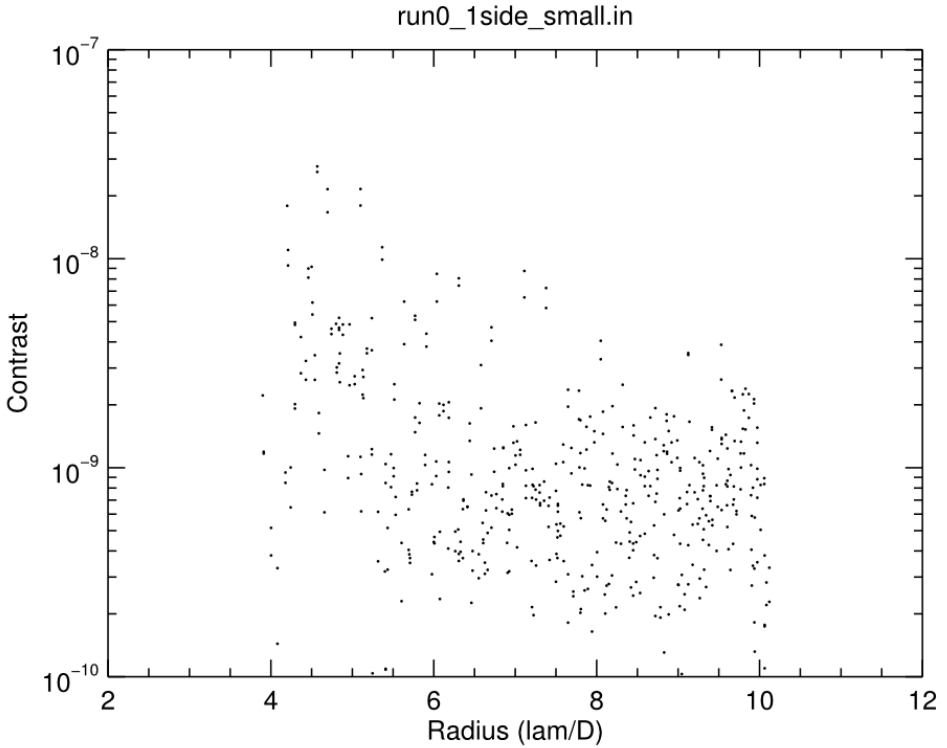
$4 - 5\ \lambda/D = 1.5 \times 10^{-8}$

1 Sided, Small Size Dark Hole

Post-EFC

With aberrations





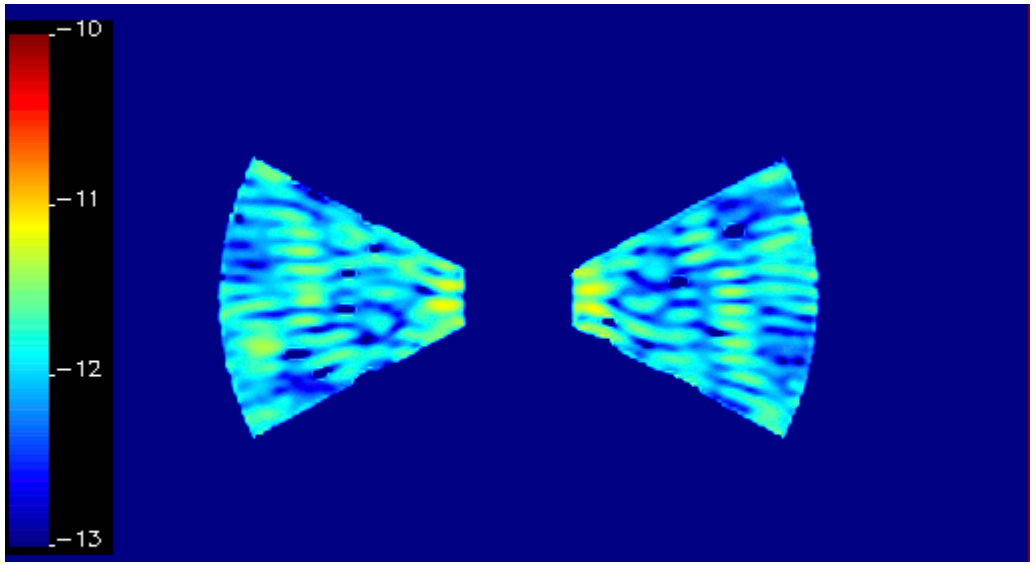
Opening angle = 56°
X ≥ 4 λ/D, R ≤ 10 λ/D

Mean contrast (full field) = 1.5×10^{-9}
4 – 5 λ/D = 5.3×10^{-9}

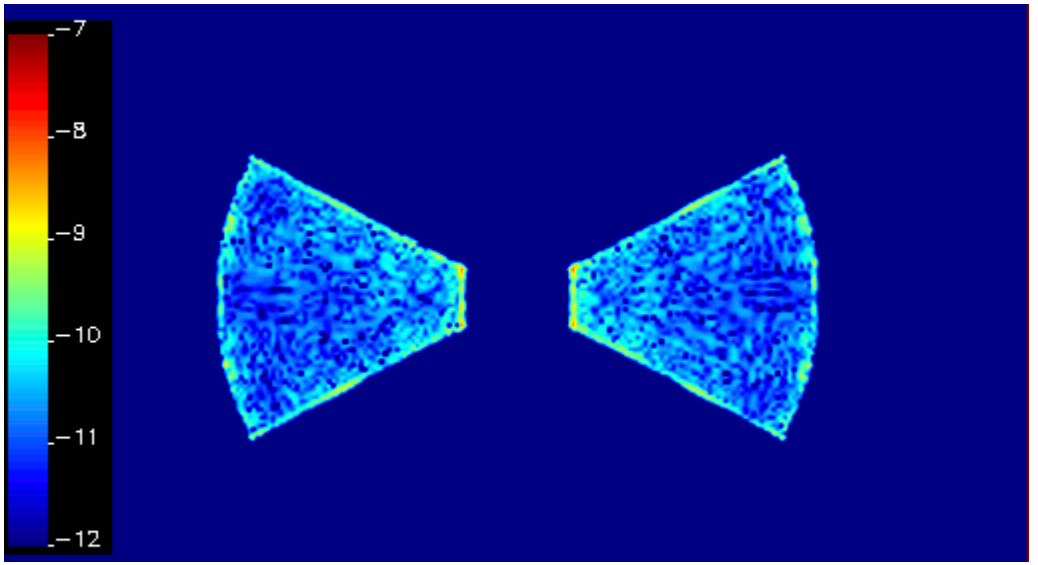
Shaped Pupil Jitter Response

Post-EFC aberrated fields

14 mas RMS body jitter – 0 jitter



1.6 mas RMS FSM jitter – 0 jitter



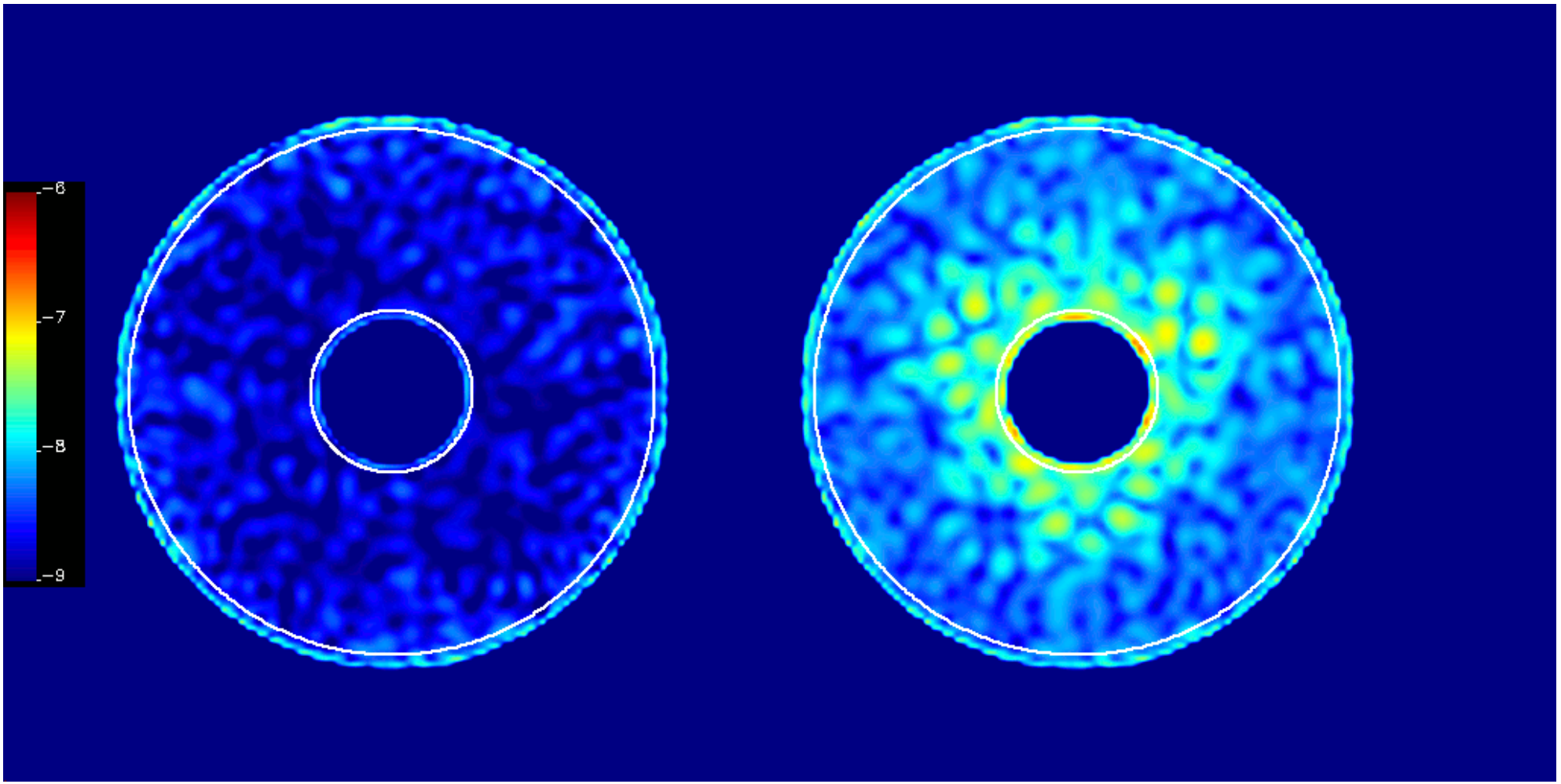
Jitter perfectly removed at FSM

HLC Jitter Response

Post-EFC aberrated fields

No Jitter (2.2e-9)

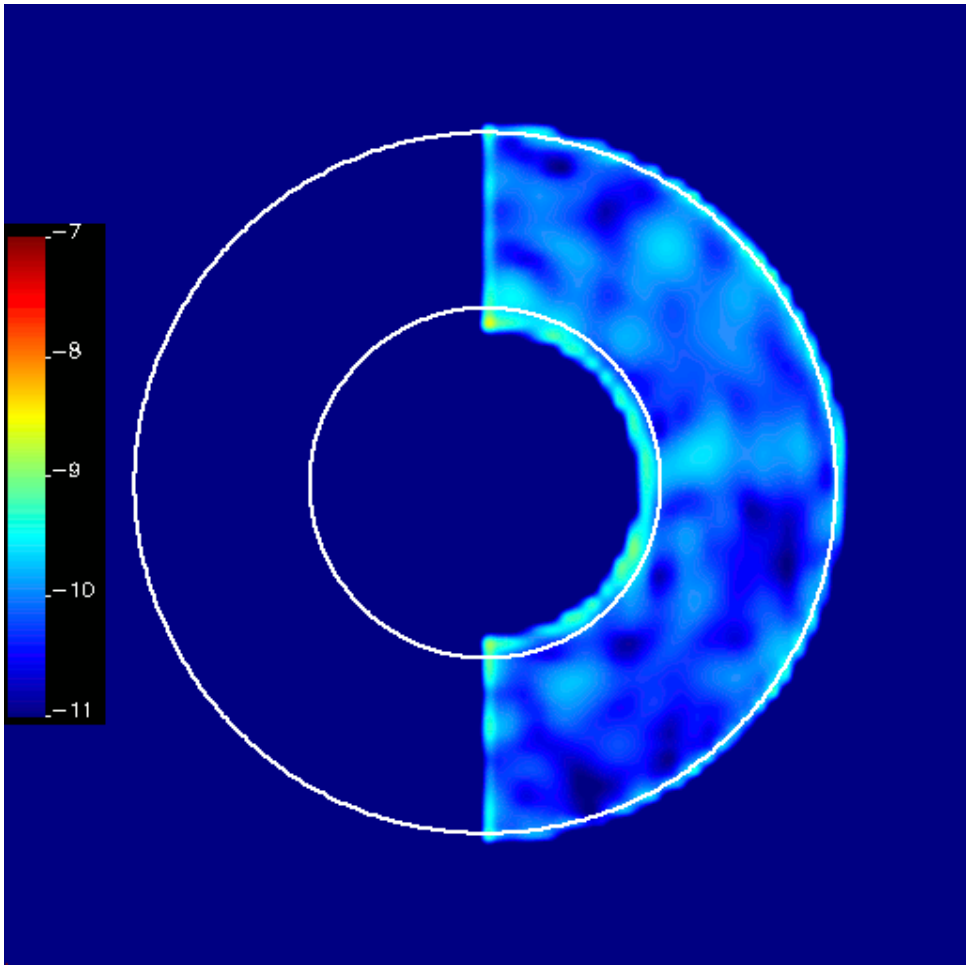
1.6 mas jitter



Circles are r = 4 and 13 λ/D

HLC Small, 1-Sided Dark Hole

1.0e-10



Circles are r = 4 and 8 λ/D

Modeling Status

- HLC
  - Simple to represent, preliminary versions have already been fully modeled
- Shaped pupil
  - Preliminary versions fully modeled, sensitivities delivered (hybrid pupil + DM version verified but not end-to-end modeled)
- VVC + shaped pupil + ACAD
  - ACAD propagation verified (remapped pupils as expected)
  - spot or no spot on vortex mask?
- PIAACMC
  - Early monochromatic result verified
  - Small focal plane mask requires separate modeling stage to represent at high resolution, requires more time
  - Need to evaluate remapping via interpolation (fast) vs explicit propagation (slow)